CLASSIFICATION CONFIDENTIAL CONFIDENTIAL CENTRAL INTELLIGENCE AGENCY

INFORMATION FROM FOREIGN DOCUMENTS OR RADIO BROADCASTS

CD NO.

COUNTRY German Democratic Republic

SUBJECT

Scientific - Engineering, metallurgy

DATE OF

INFORMATION 1951

HOW

PUBLISHED Monthly periodical

DATE DIST. 26 Feb 1952

WHERE

PUBLISHED Berlin NO. OF PAGES 10

DATE

PUBLISHED

Jun 1951

SUPPLEMENT TO

LANGUAGE

German

REPORT NO.

THIS IS UNEVALUATED INFORMATION

SOURCE

Metallurgie und Giessereitech.ik, Vol I, No 6, 1951, pp 174-180.

INCREASING THE OUTPUT OF OPEN-HEARTH FURNACES FOR PRODUCING CAST STEEL

Karl-Friedrich Luedemann

Tables and figures referred to are appended.

In an attempt to fulfill the 1950 plan ahead of schedule, the steel plants of the German Democratic Republic started a program to reduce the time required for each individual melt in open-hearth furnaces. This included better organization of the work of the crews and technical means of accelerating the process, such as adding of molten pig iron and blowing in of oxygen or compressed air. This program was adopted not only by the large steel mills, but also by the casting departments operating smaller sized open-hearth furnaces. The smelting operations had previously been considered to be of secondary importance by the casting departments, but it has now been realized that these furnaces can be used to good advantage for the production of high-grade steels to be cast as ingots for forging or rolling.

We shall report here on the success achieved along these lines by the open-hearth department of a central German steel mill. The increase in efficiency depends on three factors, of equal importance: increase of the furnace output, shortening the periodr during which the furnace is out of operation, and increasing the longevity of the furnace. We shall discuss only the first of these points in detail, and touch upon the others only as necessary. First, we must determine the standard output for a furnace of a definite melt capacity and corresponding hearth area.

Normal Output of German Cast-Steel Furnaces

The standards were determined by Guthmann, in 1943 (Guthmann: Kennzahlen Deutscher Siemens-Martin Oefen /Characteristic Data of German Open-Hearth Fur-Report No 68 of the VDEh, June 1944). Furnaces producing at least 50%

- 1 -

CONFIDENTIAL CLASSIFICATION X NAVY STATE / NSRB DISTRIBUTION ARMY

CONFIDENTIAL

CONFIDENTIAL

cast steel are classified as cast-steel furnaces. Their size varies between 3 and 33 tons. The characteristics are shown in Figure 1, which shows the standard values for hearth area, output per hour, and total melting time. Two curves are shown for output per hour and for total melting time. The broken line shows the melting time from the start of the charge to tapping, while the solid line includes nonoperating periods up to 30 min, especially the time between tapping and recharging. These data apply to the plant which is being discussed.

The Steel Mill

The mill has three generator-gas-heated basic open-hearth furnaces, built in 1939 - 1940 (furnaces I and II) and 1944 (furnace III) with a melt weight of 10 tons. They have standard Siemens heads. In 1947, they were equipped with Crespi hearths and in 1949 oblique tar-dolomite mixture real walls were installed. Following are the principal dimensions of furnace III; the other two furnaces differ only slightly.

Data in Table 1 require some explanation. While the dimensions given are for a 10-ton furnace, the melt weight has been increased in the course of time to from 13 to 25 tons, with an average of 18 tons, without any ill effects on operation. Only the hearth area had to be increased, the depth of the bath decreased, and the space between bath surface and crown increased, as shown in the table. No other modifications were carried out. The doors had been widened from 0.80 to 0.83 m and heightened from 0.80 to 1.05 m as early as 1948 to make charging easier.

As for the angle of the gas and air conduits, about half of the intersecting square formed by lengthening the gas and air intakes lies on the surface of the bath and the distance of the center of the square from the mouths of the conduits is about 28 percent of the hearth length. The cross section of one rising gas shaft is adequate, while the two air shafts should be increased to an area of 0.50 to 0.54 sq m. The content and checkerwork space of the gas and air checker chambers are more than adequate, and correspond to the dimensions of a 13-ton furnace. The cross sections of the shaft openings of the Forter valve and of the air reversal valve are very narrow, and would have to be expanded by 40 to 50 percent to be considered satisf ctory.

The chimney dimensions originally were poorly adapted to the furnace dimensions. Draft was greatly dependent on air temperature and direction and force of wind. The height of the chimneys has been increased from 36 to 41 m, and these effects have thereby been eliminated, so that an even draft of about 22 mm water column is now main sined.

Each furnace head is cooled by two water pipes of about 1 1/4 in, arranged in a semicircle around the gas conduit. Water-cooled door frames are to be installed as soon as continuous water supply can be guaranteed.

The longevity of the furnace heads from the first to the third quarter of 1950 was about 165 melts, that of the crown, 320 melts. Repairs are regularly carried out over the week end and, since 1948, it has therefore not been necessary to carry out special repairs during the regular work week. This greatly increased output and quality.

The gas-generator plant, installed in 1947, originally consisted of two rotary grates with a masonry-shaft diameter of 2.2 m and a rotary grate with a shaft 2.6 m in diameter. Brown-coal briquettes with an addition of open-burning coal were used to produce the gas. The installation, as a rule, was operated in such a way that the 2.2-m gas generators jointly supplied one furnace, while the 2.6-m generator supplied one furnace by itself. The throughput of the 2.2-m generators was 96 kg/sq m hr each, that of the 2.2 m gas generator, 120 kg/sq m hr.

- 2 -

CONFIDENTIAL

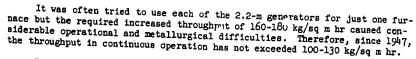


Declassified in Part - Sanitized Copy Approved for Release 2011/10/31 : CIA-RDP80-00809A000700040387-7

50X1-HUM

CONFIDENTIAL

CONFIDENTIAL



In the third quarter of 1950, another 2.6-m gas generator was installed, and three-furnace installation replaced the old two-furnace system. Local conditions made it impossible to install a joint gas line to the furnaces. The gas is piped to the furnace from each of the 2.6-m generators, and from the pair of 2.2-m generators in subterranean, noninsulated conduits, 15-17 m long and with a 0.5 sq m cross section. The conduits are cleaned on Sundays.

Until March 1948, one 5-ton bridge crane was available for charging with scrap and pig iron at for moving the charge to the charging box. Then, an additional 5-ton rane was installed. In 1950, the number of scrap cranes was increased to three. From the charging boxes, the charge is placed into the furnace with a 1-ton charging crane. Installation of a second charging crane is planned.

The production program includes mainly carbon steels for castings and forging and rolling ingots; but small quantities of alloy steel are also made. In general, the scrap pig-iron method, with a pig-iron charge of about 18-22 percent, is used. During times of pig-iron shortages, the scrap-coal method had to be used occasionally during the past years, with less than 10% pig-iron charge, and a resulting drop of 10-15% in production.

Furnace Output

Operations at the plant were resumed toward the end of 1949, after a stoppage of nearly 1 1/2 years. The difficulties caused by the postwar conditions were not overcome until the fourth quarter of 1947, when an hourly output of 1.59 tons, including the time for patching the tap hole, was reached with 10- to 11-ton melts. In the second quarter of 1948, it increased to 1.79 t/hr and in the fourth quarter of 1949, it reached 2.14 t/hr. This means a 34.7 percent increase in hourly output, and an increase in the production of molten

In October 1949, operation with higher melt weights was started. Due to the fact that the crane capacity in the casting department was inadequate, this was a gradual process which did not show any effects until the first quarter of 1950, at which time an hourly output of 2.32 t/hr with a mean melt weight to a hearth surface output of 213 kg/sq m and to the normal output of a 40-ton molten charge.

As the crane installations are capable of pouring no more than 11 tons of steel, tapping into two ladles had to be carried out with larger melts. The cascade method with two ladles turned out to be very suitable, especially since the tapping temperature of 1,570-1,600°C (uncorrected) was too high. This method is still in use. Experiments were made on individual 25-ton melts with a tilting double trough and three ladles. This method, however, required tedious preparatory work, and impaired the quality of the steel because it formed vortices at the fork in the trough. The Steinheisser trough, although definitely superior, has not yet been tried, because major modifications on the casting cranes would be required to allow its use.

- 3 -

CONFIDENTIAL



Declassified in Part - Sanitized Copy Approved for Release 2011/10/31 : CIA-RDP80-00809A000700040387-7

50X1-HUM

CONFIDENTIAL

CONFIDENTIAL

Causes of Higher Efficiency

The activist movement led to the organizing of competitions between filt-vidual shifts in an attempt to cut down the time required to produce one melt without lowering itr quality. Table 2 shows the results of these competitions. The melting time given is the time from the beginning of the charging operation to the removal of the first preliminary sample from the furnace. The time required for patching the tap hole is not included. These melts were used mainly for wheel disks and castings.

The processing of the melt is shown by the data in Table 3. The melts produced no waste due to inferior quality. Frame that the boiling time of 1.5 hr would be too short turned out to be groundless. This has been proved repeatedly since then.

In February 1950, the operations were definitely converted to melts above 11 tons. Melts of 11 tons are run only occasionally, for special orders, e.g., for alloyed steels.

The average hearth surface output of 318 kg/sq m/hr leads us to state that literature contains no data which indicate that such high efficiency has ever been achieved before under similar operating conditions.

The technical measures taken to achieve this performance were chiefly the following:

- Proper preparation and mixing of the charge, so that charging time can be kept low and the correct analysis maintained.
- Melting with high flame, i.e., a maximum gas supply and corresponding volume of air, to achieve high bath temperature at the start of the boiling process and to permit violent start of the metallurgical reactions.

Concerning point 1, the effect of charging time on melting time, boiling time, and thus on the total melting time, was investigated on a large scale. Figure 2 shows the results plotted for a 1-ton melt, with melting time, boiling time, and total melting time as function of the charging time. It is obvious that this effect is a very pronounced one and that all measures improving the preparing of the scrap and the charging technique are definitely worth the trouble.

These measures included the maximum development and maintenance of the scrap cranes and charging cranes, installation of a sufficient number of charging boxes, and educating the charging personnel to proper utilization of charging box space. Some success has been achieved in this respect: for more than 50 percent of all melts, the charging time was less than 5.8 min/t, although the scrap was not in good condition. However, full success will have been achieved only when this time has been cut down to a maximum of 4 min per ton, despite the unwieldiness of the scrap.

The dependence of the boiling time on the charging time should be noted. Well-prepared and quickly charged melts have the lowest boiling times. Charging times of 6-13 min/t do not affect it, while longer charging times may prolong the boiling time. In that case, the melt is usually too soft, and requires the addition of carbon, which causes considerable loss of time.

- 4 -

CONFIDENTIAL.



CONFIDENTIAL

CONFIDENTIAL

Concerning point 2, Figure 3 shows the operating condition of a furnace during the melting process, with the tables giving the temperature, draft, and pressure at the points indicated. The furnace represented here is furnace I, heated by the 2.6-m gas generator IV which was built in 1950. The hourly output of the two melts on which the measurement was made was 3.57 and 3.35 t/hr, which is fairly high. Despite the high melt weights, the tapping temperatures were at the upper limit.

The furnaces are supplied with combustion air by a 3,000 cu m/hr blower which is fully utilized. The gas generator, in the case under discussion, was operated on a 1:1 mixture of lignite briquettes and open-burning coal. The throughput of practically dust-free mixture was 118 kg/sq m/hr; 2.83 cu m of gas were generated per kilogram of mixture with 1.95 cu m/kg of combustion air.

The temperature of the steam-air mixture was maintained at 55° C. The fuel consumption is 200 kg of standard coal per ton of liquid steel (the mixture coal converted into standard coal with a lower limit of the thermal value of 7,000 kcal/kg). This is an extraordinarily low consumption figure. The consumption of the entire installation, in November 1950, was 240 kg of standard coal per ton of steel, including the periods during which the furnaces were empty and kept heated. Each gas generator is equipped with instruments measuring and recording forced draft, gas pressure, steam-air mixture temperature, and the gas temperature in the exhaust stack. The furnace is equipped with devices indicating the temperature of the gas chambers at the top of the checkerwork, the exhaust temperature, the pressure and draft in the reversal conduits, and the chimney draft. All these measuring and recording devices are again being manufactured with adequately exact indication and sufficiently high safety factors.

Increase of Output by Charging With Premolten Pig Iron

The advantages of the use of molten pig iron in the scrap pig-iron method, especially in cutting down the melting time, are used mostly where the pig iron can be transported directly from the blast furnice to the openhearth furnace. In the steel mills of the German Democratic Republic, this is not possible as yet. It is important to determine, however, what increase in output can be achieved by charging with steel pig shipped in in the solid state and then molted, or by the use of steel pig artificially made from steel and casting scrap in a cupola furnace. This method has been known for a long time, and according to a report by Herzog in Stahl und Eisen, Vol 46, 1926, proved to be entirely satisfactory. It is thus surprising, that the use of premelted pig iron has never been adopted by German steel mills.

Table 4 gives the results of two experimental series of melts which were made by this process. They were conducted in November 1950, each comprising five melts. The steel pig was first melted in a 2.5-ton Fiat electric-arc furnace and poured into the open-hearth furnace through a trough in the rear. Unfortunately, the measuring instrument failed and the charging temperature could not be determined. The two series also differ in that the furnace was operated only with a 2.2-m gas generator during series I, because the second gas generator was being repaired at the time, while two 2.2-m generators were used for the second series. The steel pig was poured into the furnace no later than 45 min after charging the furnace with scrap; thus there were still piles of scrap in the furnace at the time.

The melts of the first series showed an 18.7-percent increase in output over the normal output with a solid steel pig charge, while the second series, carried out with a more adequate gas supply, showed an increase of 33.0 percent. In practice, premelting of the steel pig will have to be carried out in a cupola furnace, and the lower tapping and charging temperature will not

-5-

CONFIDENTIAL



Γ

50X1-HUM

CONFIDENTIAL

shorten the open-hearth melting time as much as the use of an arc furnace will. The arc furnace, however, was used only experimentally, but above tests prove that thebuilding of a pre-melting installation would be justified by the results achieved with it. The economy of such a method will be guaranteed only -- under the conditions prevailing at present -- when sufficient steel pig can be made in a cupola furnace by means of an "economy mixture." At present, work is progressing on this question, and some very promising results already have been obtained.

It was also attempted to duplicate the output obtained with a molten steel pig charge by using solid steel pig. Figure 4 shows the result for 79 successive melts of 13 to 25 tons weight, with the melt weight as the ordinate and the hearth area output and the hourly output as the abscissae. The highest output in each weight group is marked. The outputs for the various weight groups, obtained between June and October 1950 and considered as normal, are plotted for commarison. The graph shows, first of all, that individual melts with solid steel pig showed even higher output than obtained in the other test series with molten steel pig, while the average output of the furnace was increased over the previous months.

Tables and figures follow.

Te	.	۱.	٦.

	Up to Mar 1950	Since Mar 1950
Melting space		
Length of hearth at level of fore plate	5.20.m	E 70 -
width of hearth at level of fore plate	2.10 m	5.70.m 2.10.m
hearth surface at level of fore plate	10.90.sq m	11.80 sq m
Calculated mean depth of bath	157 mm	145 mm
Maximum depth of bath	450 mm	415 mm
Distance between surface of bath and crown	1.25 m	1.40 m
Gas and air conduits	1.c./ m	T-40 m
Number of oblique gas conduits	1	
Height at mouth	0.30) m
Width at mouth	0.50	
Cross section at mouth		
Angle	14	o ^{sq m}
Number of oblique air conduits	1	•
Height at mouth	0.30)
Width at mouth	1.20	
Cross section at mouth		sq m
Angle	250	
Air conduit width/gas conduit width = 1.20/0).50 = 2.4	
Rising gas and air shafts per furnace side	•	
Cross section of one gas shaft 0.50:0.50 =	0.25	sq m
Cross section of one air shaft 0.40.0.45 =		sq m
Cross section of both air shafts	0.36	sq m
Gas and Air Chambers	-	•
One gas checker chamber		
Gas chamber content	19.83	cu m
Width of checkerwork	2.55	
Depth of checkerwork	2.10	m
Height of checkerwork	2.70	m
Checkerwork space	14.47	cu m

- 6 -

CONFIDENTIAL



CONFIDENTIAL.

• ••	CONT	DEILIHT.	
	CONFIDEN	TIAL	
		Up to Mar	Since Mar
		1950	_1950
			19)0
l air checker chamber			
Content			23.67 cu m
Width of checkerwork			2.10 m
Depth of checkerwork			3.20 m
Height of checkerwork			2.70 m
Checkerwork space			18.14 cu m
Both checker chamber pair	8		
Gas chamber content	2•19.83 =		39.66 cu m
Air chamber content	2•23.67 =		47.34 cu =
	Total		87.00 cu m
Gas chamber checkerwork		2:14.47 =	28.94 cu m
Air chamber checkerwork	space	2·18.14 =	36.28 cu m
		Total	65.22 cu m
Total checkerwork space	/total chambe	er content 65.22/	87.00 = 0.75
Reversal ducts			
Cross section of gas reve			0.50 sq m
Cross section of air reve	rsal duct		0.65 sq m
Valves			
Gas valve (Forter type)		. 15 . 6	
One chamber shaft valve		0.45 .0.60 =	0.27 sq m
One chimney shaft valve		0.45 .0.60 =	0.27 sq m
Fresh gas nozzle 0.60 d			0.28 sq m
Air valve (reversal valve		0 (0 :0 (0 =	0.06
One chamber shaft valve		0.60 (0.60 =	0.36 sq m
One chimney shaft valve		0.60 -0.60 =	0.36 sq m
Air nozzle 0.60 dia			0.28 sq m
Chimney flues	-1		0.70
Chimney flue behind air v			0.72 sq m 0.90 sq m
Chimney flue behind gas v		\	0.90 sq m
Main chimney flue (joint Chimney	AGR NG REE IT	ие /	о. 30 ву ш
Height above floor of mil	1		36 m
Height above bath level			30 m
Cross section at base			2.54 sq m
Cross section at mouth			1.13 sq m
OT ORB BECCTOR OF WORLD			J -4

Table 2. Melts With Exceptionally High Output (10.8 sq m furnace)

No		<u>Unit</u>	Nov 1948	0ct <u>1949</u>	Feb 1950
1.	Number of melts		26	10	16
2.	Weight of melt	tons	10,200	11,000	18,750
3.	Charging time	hr	1:04	1:00	1:42
ŭ.	Melting time	hr	2:34	2:27	3:41
. 5.	Boiling time	hr	1:30	1:21	1:46
6.	Total melting time	hr	4:04	3:48	5:27、
7.	Furnace output	tons/hr	2.51	2.90	3.44
8.	Hearth surface output	kg/sq m hr	232	268	318

- 7 -CONFIDENTIAL



Γ

50X1-HUM

CONFIDENTIAL

Table 3. Metallurgical Characteristics of Melts With Exceptionally High Output

ĽΩ		Unit	Nov 1948	0e ն <u>1949</u>	Feb 1950
2.	Weight of melt Level of C-content of preliminary sample above	tons	10,200	11,000	18,750
3. 4. 5.	that of final sample Average decarbonization rate Slag content Tapping temperature (not	% C/hr	0.48 0.32 12 15	0.51 0.33 13	0.50 0.29 13
6.	corrected) Pouring temperature (not corrected)	o _C	1,585	1,590	1585/1570*
	lst lsdle (start/end) 2d ladle (start/end)	0 C 1	,490/1,440 	1,480/1,430	1,480/1,430 1,465/1,425

^{*} Tapping temperature of first and second ladles with use of cascade method.

Table 4. Improvement of Furnace Output by Use of Premolten Steel Pig (average values)

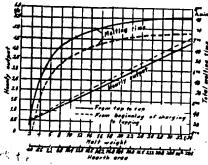
	No of Melts	Melt Wt (tons)	Molten Steel Charge (%)	Melting Time (hr)	Hourly Output (tons/hr)	Normal Output With Solid Steel Pig Charge (tons/hr)	Increase Obtained,
Series I 1 gas generator of 2.2 m	5	18.500	16.2	6:04	3.05	2.57	1 0. 7
Series II 2 gas generator of 2.2 m	5	18.550	17.0	5 :2 5	3.42	2 . 57	33.0

-8-

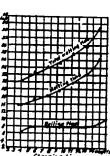
CONFIDENTIAL

CONFIDENTIAL

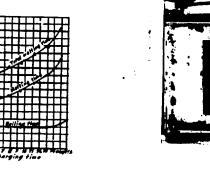
CONFIDENTIAL



Relationships Between Hearth Area, Melt Weight, Hourly Output, and Melting Time in Steel Furnaces Figure 1.



"igure 2.



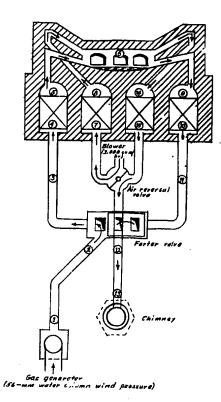


Figure 3. Fesults of Temperature, Draft, and Pressure Measurements on Open-Hearth Furnace I, With Tables Showing Results of Melts and Tapping and Pouring Temperatures (Measured on 1 November 1950)

-9-CONFIDENTIAL

CUNFIDENTIAL

CONFIDENTIAL

Temperature, Draft, and Pressure Measurements During Melting

Measuring point	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature O C Draft, mm water	570	360			1,040	1,780			1,120	 -13	 -16	440 -17	380 18	₇	 -8
Pressure,"	+32	+13	+10	+9	+8	+1	+1	+2		-•		•			

Gas Analysis and Thermal Value

CO2	$C_{22}H_{22}$	02	c o	H ₂	$\mathtt{CH}_{l_{l}}$	N ₂	H _u
5.0%	0.25	0	28.0%	15.6%	2.3%	48.9%	1,484 kcal/M cu m

Results of Melts

Melt No	Melt Wt	Charging Time (hr)	Melting Time (hr)	Boiling Time (hr)	Total Melting Time (hr)	Hourly Output (t/hr)
7,862	24.75	1:50	4:35	2:10	6:55	3-57
7,864	21.45	1:45	4:45	1:50	6:25	3-35

Tapping and Pouring Temperatures, Not Corrected

Melt No	Tapping Temp	Ladle No	Pouring T	emp (^O C) <u>End</u>	Steel Quality
7862	1,600	· I	1,500 · 1,480	1,450 1,430	52:81
1,864	1,590	I II	1,550 1,490	1,440 1,430	52.81

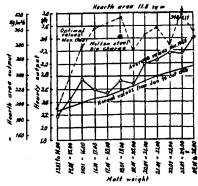


Figure 4. Improvement of Hourly Output and Hearth Area Output of Open-Hearth Furnace I in November 1950 (evaluation of 79 melts with solid steel nig charge)

- E N D -

- 10 -

CONFIDENTIAL

